

Kinetic Auto Relay

electromechanics by the square centimetre

By S. van Rooij

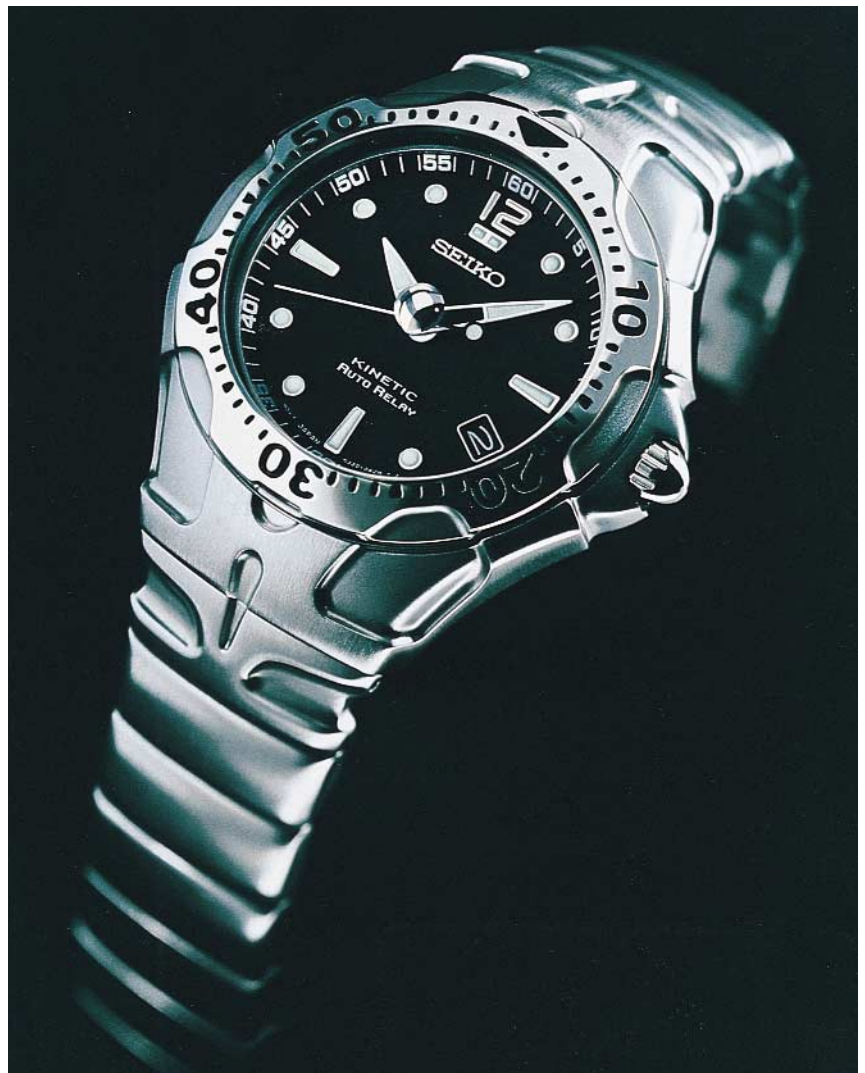
Seiko recently introduced a new line of wristwatches under the somewhat cryptic name of 'kinetic auto relay'. The internal construction of these watches will certainly interest electronics engineers. They are such magnificent examples of technical ingenuity that the fact that they also keep very exact time will probably be of secondary importance to the true enthusiast — even if it is naturally a nice side effect.

What do wristwatches have to do with electronics? Previously, the answer was 'nothing at all', but nowadays the two have steadily more in common. In any case, we can say that the boundary between the two disciplines is becoming increasingly vague, as a consequence of ongoing digitalisation and integration. A digital camera, for example, is a long way removed from its original, purely optomechanical roots. It is not at all a mechanical device any more, and it could just as well be described as a 'mini-computer with an optical interface'.

For some time now, a similar situation has prevailed with modern watches. Of course, this is obviously true of digital watches with liquid crystal displays, but even in the case of an analogue quartz watch, a traditional watchmaker would look in vain for his familiar gearwheels. A battery, an oscillator and a stepper motor are about all that you will find inside a modern quartz watch. This is all you need to make a watch that will keep accurate time, but it's not really an interesting piece of technology — certainly not for a watchmaker, but also not for an electronic engineer.

Automatic

The watch industry has not turned completely to quartz, in spite of appearances. One type of watch that has managed to survive very well, and that still has not yielded to the flood of quartz mechanisms, is the automatic watch. Such a watch can be recognised by the label



'automatic' on its dial.

An automatic watch is an old-fashioned type of watch, full of genuine gears, pawls and springs. It is called 'automatic' because it continuously winds itself from the movement of the wearer's wrist. This necessary energy comes from an eccentrically mounted weight that is coupled to the mainspring of the clockwork. The highly coveted Rolex still works on this principle, as do several other exclusive Swiss models.

You could of course decide to buy such an automatic watch for purely nostalgic reasons, since it is a nicely old-fashioned piece of technology. However, an automatic watch also has a true advantage with respect to a modern quartz watch, in that you will never be stuck with an empty battery at an inopportune moment. Against this stands the disadvantage that a mechanical watch can never be as accurate as a quartz watch.

Kinetic

A number of years ago, Seiko made a successful attempt to combine the advantages of automatic watches with those of quartz watches. They started with the same sort of eccentrically mounted moving weight that is the hallmark of all automatic watches. However, instead of using this to wind a spring, they used it to drive a miniature generator. This was very clever on the part of the developers, since the generator was used to charge a battery or a capacitor, which in turn supplied power to — you guessed it — a quartz movement! In this way, they created an automatic watch that can offer the high accuracy of a quartz watch. In addition, the combination of a generator and a capacitor turns out to yield a much greater reserve capacity than the spring of a classic automatic watch. Normally, a spring cannot drive a watch for more than one or two days if the watch remains stationary, but the generator can build up a reserve that can power the watch for several weeks. Seiko gave the new drive technology the name 'kinetic'. Over the last few years, watches based on this principle have developed into a reasonably



Figure 1. In both 'automatic' and 'kinetic' watches, kinetic energy is converted into stored energy for operating the clockwork. No batteries needed!

successful alternative to traditional automatic watches.

Auto-relay

With the recent development of the 'kinetic auto-relay' watches, Seiko has once again shown that they are a trend-setter in modern watch tech-

nology. These watches contain an additional, intelligent control chip, which allows the energy reserve time to be extended to at least four years. If the watch remains stationary for three days in a row, this chip causes the hands of the watch to be stopped. As soon as the watch is picked up again after such a dormant period, its hands are automatically set to the correct time.

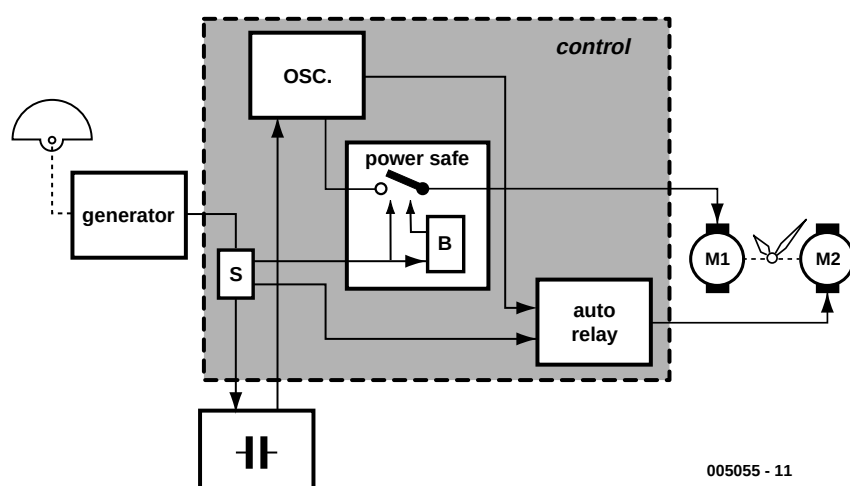


Figure 2. Simplified block diagram of the 'kinetic auto-relay' system.

The idea behind this new development is actually quite simple. At some point, Seiko realised that the actual clockwork (the oscillator) consumes only 15 percent of the energy needed to run the watch, while the remaining 85 percent is used to drive the hands. This means that if the reserve time is to be increased, the means to do so must be sought in the drive mechanism for the hands.

This is however easier said than done. Stopping the hands is naturally not all that difficult, but setting them to the correct positions after a dormant interval is another story. Still, this problem has been solved with the help of a clever controller and an extra stepper motor.

Figure 2 shows a simplified block diagram of the auto-relay system. The generator (plus the rotating weight), the quartz crystal oscillator, the capacitor or battery used to store the energy and the stepper motor (M1) are all elements that are used in the 'standard' kinetic system. The new elements are the sensor (S), the buffer (B), a second stepper motor (M2) and the 'power safe' and 'auto relay' blocks.

In general, the system works as follows. When the watch is being worn, so that the rotating weight occasionally moves, the generator delivers a charging current to the capacitor more or less regularly. The capacitor provides the oscillator with its operating voltage, so that the oscillator can drive stepper motor M1, which in turn drives the hands.

If the watch does not move, no charging current is generated. Sensor S (which in principle is just a shunt resistor) detects this fact and generates a command. This causes the 'power safe' block to de-assert the enable signal for the switch that connects the oscillator to motor M1. However, this does not have an immediate effect, since the buffer B holds the switch enabled for 72 hours. At the end of this time, the control signal for M1 is interrupted and the hands stop moving.

When the watch is moved again after some time, the generator will again produce a charging current. The sensor detects this and passes this information on to the 'auto relay' block. This block compares the position of the hands to the current time, as provided by the oscillator. This block then positions the hands to the correct time, moving the hour and minute hands first and then the seconds hand. The only thing that has to be set manually is the date display (if one is present), since automatically setting this would consume too much energy.

The normal hand drive mechanism (with motor M1) is also re-enabled via the 'power save' block, so that the watch again runs normally.

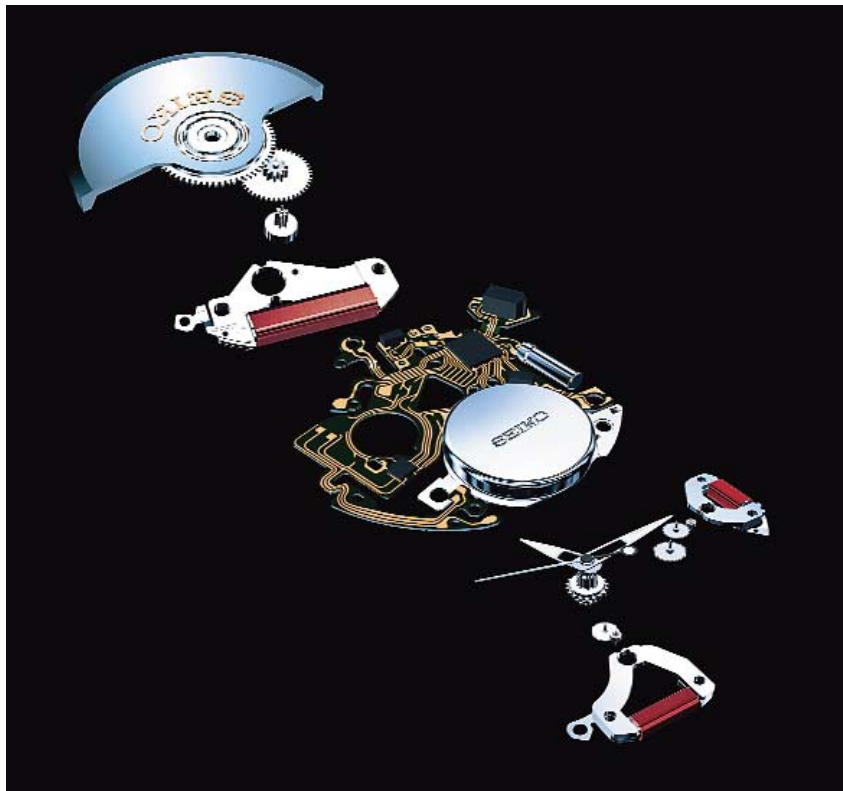


Figure 3. Exploded view of the interior mechanism of the watch. The chip located on the circuit board controls all functions of the watch.

Internal details

A block diagram of how the watch works is naturally nice, but a look inside the actual mechanism is much more informative. The internal elements of the new 'auto-relay' mechanism are shown in some detail in **Figure 3**. For clarity, the various elements have been spread out in this illustration, since it's difficult to see how they are built when everything is assembled in its working configuration.

At the top, you can see the rotating weight, which weighs around five grams. It is mounted in low-friction bearings, so that it changes position every time the wearer's wrist moves. The rotating weight drives a minuscule rotor via a two-stage gear train. The motion of the rotor induces a current in the stator coil, which is shown below the rotor. The rotor is not much larger than the head of a pin, and it can spin at up to 100,000 rpm.

Below this, you can see the printed circuit board, which has a cutout in the middle for the controller chip. The quartz crystal for the oscillator is located on the right hand

edge of the circuit board, and the 'energy storage unit' is clearly visible below the circuit board. Previously, a capacitor was used for energy storage, but the specifications presently provided by the manufacturer suggest something more like a rechargeable battery.

Finally, at the very bottom, you can see the hands and the two drive motors.

Working reserve

The energy storage unit (the battery) is delivered fully charged from the factory. If the power reserve somehow becomes used up, due to the watch not being used for a long time, the watch will naturally have to be worn for a while to build up a sufficient power reserve. A reserve that will last for a few days or a week can be built up very quickly, but it takes a certain amount of time to accumulate the maximum reserve capacity (four years). If the watch is worn every day for 12 hours a day, the maximum working reserve will have been built up after 168 days.

(005055-1)